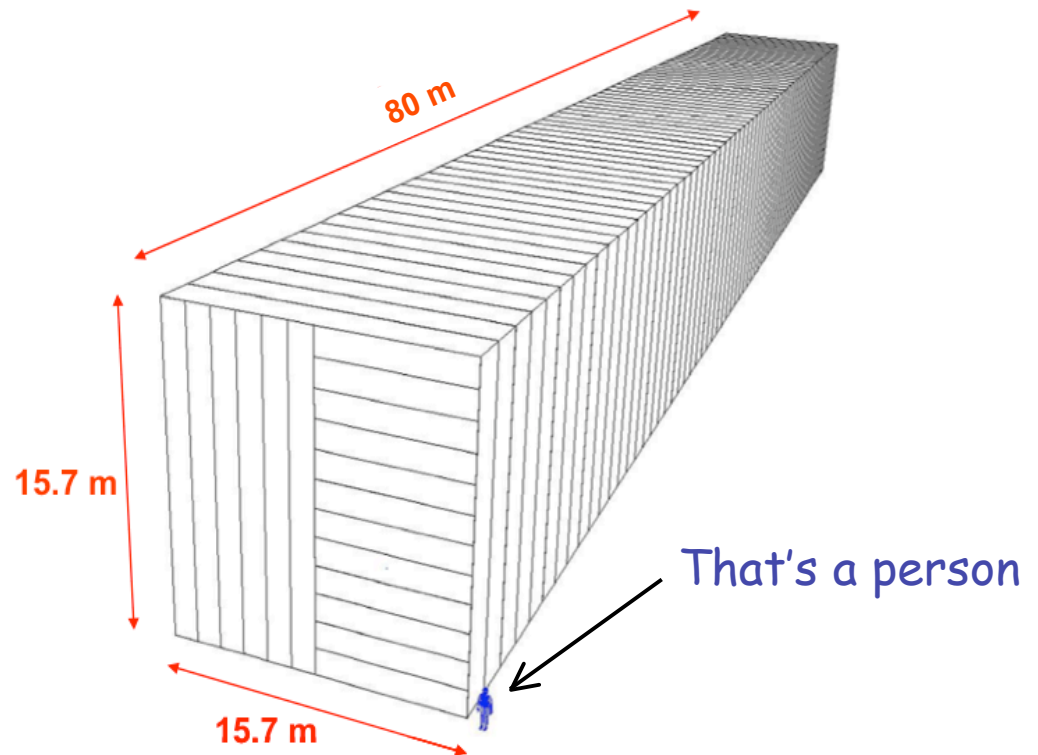




# NOvA Cost Drivers, Risk and Contingency

- The NOvA detector has a couple of unique features:
  - It's simple
  - One type of detector
  - One type of readout
  - Manageable data rates
  - No radiation issues
- It's Huge!
- Cost dominated by a small number of cost drivers





# Cost Drivers

- Far Detector Hall
- Liquid Scintillator
- PVC Extrusions
- WLS Fiber

Account for  
> 50% of the  
total project  
cost

These items are cost drivers because of the large size/volumes involved

Small price increases per unit volume can add up quickly



# Acquisition Strategy

- We have used a *graded approach* to focus on getting real cost estimates for the *cost drivers*.
- We have solicited quotes for the integration near detector prototype for delivery in 2007-2008.
- The quotes included a *unilateral option* for delivery of full quantities for the full NOvA near and far detectors beginning in 2008.
- We know the price of the cost drivers if we could buy them today. The challenge now is to understand how those costs could change between now and the time we actually buy.



## Acquisition Strategy (cont.)

- In order to account for normal changes in cost over time and to protect the interests of both sides, we have asked for a publicly available and independent scaling index to accompany the quotes.
- Possible indices include
  - Diesel fuel surcharge
  - Producer price index
  - Base oil cost published in the *Lube Report*...
- The quotes give us our base cost
- The indices help us to determine our contingency



# Contingency Determination

- For most of the items in our WBS we assign a flat rate contingency based on the Contingency Analysis Rules for NOvA (NOvA-doc-616)
- Following our Risk Management Plan (NOvA-doc-185), for items with moderate or high risk, we determine an additional risk-based contingency when appropriate.
- The different contingency pieces are statistically combined using a Monte Carlo according to the prescription in the Risk Management section of DOE Order 413.3



# M&S Contingency Rules

NOvA-doc-616

- 1) 0% on items that have been completed
- 2) 10-15% on items that have already been purchased at least once (perhaps in small quantities) or items for which there is a very firm quote and for which there is more than one potential vendor.
- 3) 15-25% on items that have already been purchased at least once (perhaps in small quantities) or items for which there is a very firm quote but for which there is likely to be only one vendor.
- 4) 25-50% on items that can be readily estimated from a reasonably detailed design or for which there exists a very close “analogous system”, with well understood costs.
- 5) 50-75% on items for which only a conceptual design exists.
- 6) 50-75% for items that have unproven yields or for which there are unique issues (e.g. an uncertain cost and a single vendor).
- 7) 70-100% for items that do not yet have a detailed conceptual design.



# Mineral Oil

- We need **3.7 M** gallons.
- In Dec. 2005 we issued an RFP with an option for **6.6M gallons** and received quotes from two vendors that are very close.
- Oil is indexed to Conoco/Phillips 70-N Paraffinic Gulf Coast Group II base oil found weekly in the Lube Report.
- Shipping is indexed to BNSF fuel surcharge rate that depends on the cost of diesel fuel
- In May 2007 we asked the two suppliers for updated quotes for the smaller quantity.
  - One supplier raised the price by \$0.05/gal to account for quantity change, one did not.
  - We have modified our cost by \$0.05/gal to reflect this change.



# Mineral Oil Price

	<b>Dec. '05 6.6M gal 30 kt</b>	<b>May '07 3.7M gal 18 kt</b>	<b>May '07 3.2M gal 15 kt</b>	<b>Dec '05 + \$0.05 Indexed to May '07</b>
<b>Base Oil Index Price</b>	\$2.62/gal	\$2.97/gal	\$2.97/gal	\$2.97/gal
<b>Vender A</b>	\$2.98/gal	\$3.33/gal	\$3.33/gal	\$3.33/gal
<b>Vender B</b>	\$2.96/gal	\$3.36/gal	\$3.36/gal	\$3.36/gal

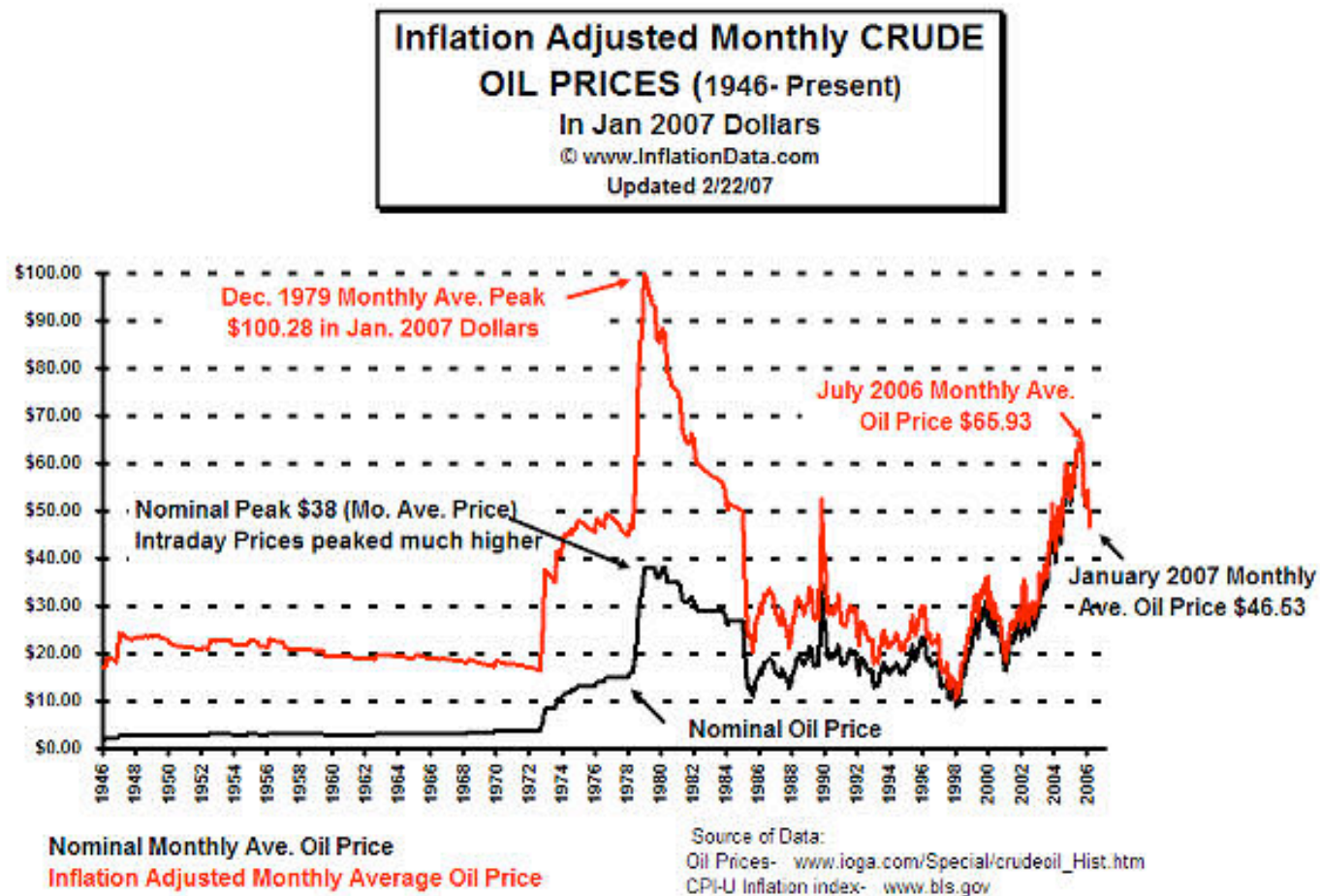
**Indexing Works!**  
Change is well within our contingency





# Mineral Oil Risk

Crude oil price volatility is one of the biggest cost risks to NOvA.

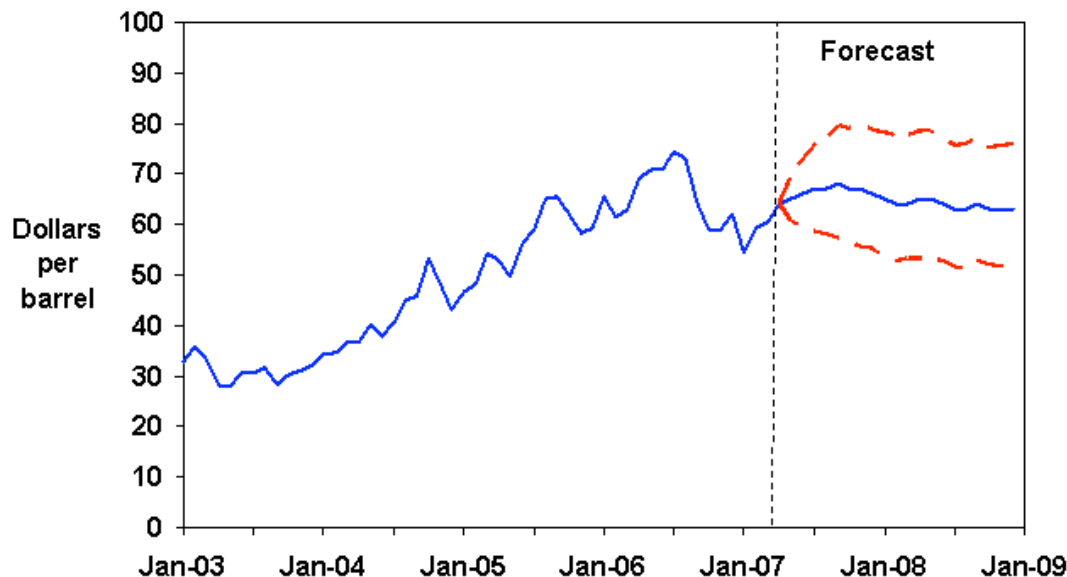




# DOE Crude Oil Price Short-Term Projections

The Energy Information Administration is an independent agency within the U.S. Department of Energy that develops surveys, collects energy data, and analyzes and models energy issues.

West Texas Intermediate Crude Oil Price  
(Base Case and 95% Confidence Interval\*)



## **From Short-Term Energy Outlook,** **DOE Energy Information Administration:**

WTI crude oil spot prices are projected to average \$64.27 per barrel in 2007, down from \$66.02 in 2006. In 2008, WTI spot prices are projected to decline slightly to an average of \$63.83 per barrel.

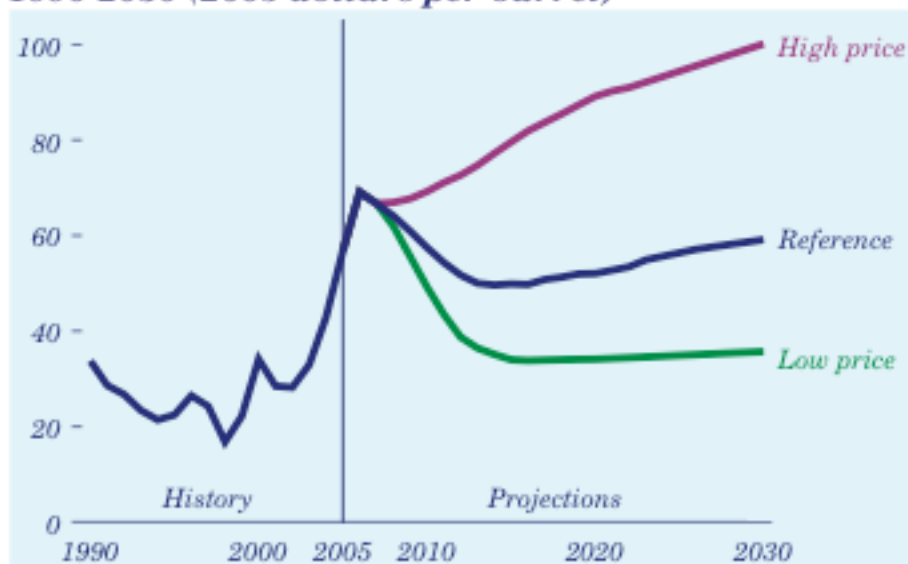
*\*The confidence intervals show  $\pm 2$  standard errors based on the properties of the model.*



# DOE Crude Oil Price Long-Term Projections

## Oil Prices Decline in the Short Term, Then Rise Through 2030\*

*Figure 10. World oil prices in three AEO2007 cases, 1990-2030 (2005 dollars per barrel)*



\*EIA Annual Energy Outlook 2006

The high and low price cases reflect different assumptions about the size of the conventional world oil resource, and they project different market shares for OPEC and non-OPEC oil production.

In the high price case, world oil production reaches 102 million barrels per day in 2030, with OPEC contributing 31 percent of total world oil production.

In the low price case, world oil production reaches 128 million barrels per day in 2030, with OPEC contributing 40 percent of total world oil production.



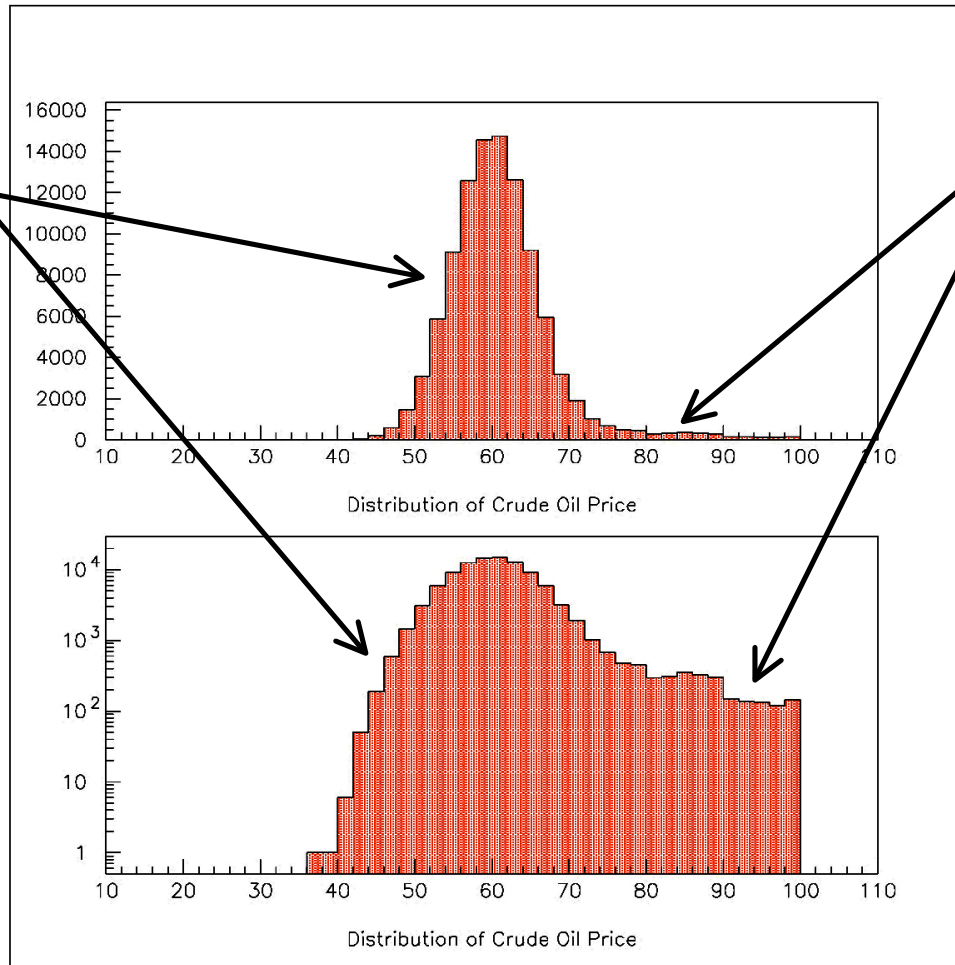
## Interpretation (cont.)

- The price of WTI crude was ~\$65/barrel when we were soliciting bids.
- Projection for Jan. 2009 is ~\$64/barrel.  
95% CL upper limit for Jan. 2009 is ~\$75/barrel.
- Probability distribution for crude oil was based on projections from a year ago:
  - A Gaussian centered at \$60 with  $\sigma = \$5.10$
  - $\Rightarrow$  95% C.L. at \$70/barrel.
- Add an additional high-side tail, based on historical data, to allow for higher prices as a result of non-market forces. No low-side tail.



# Projected Crude Oil Price Distribution

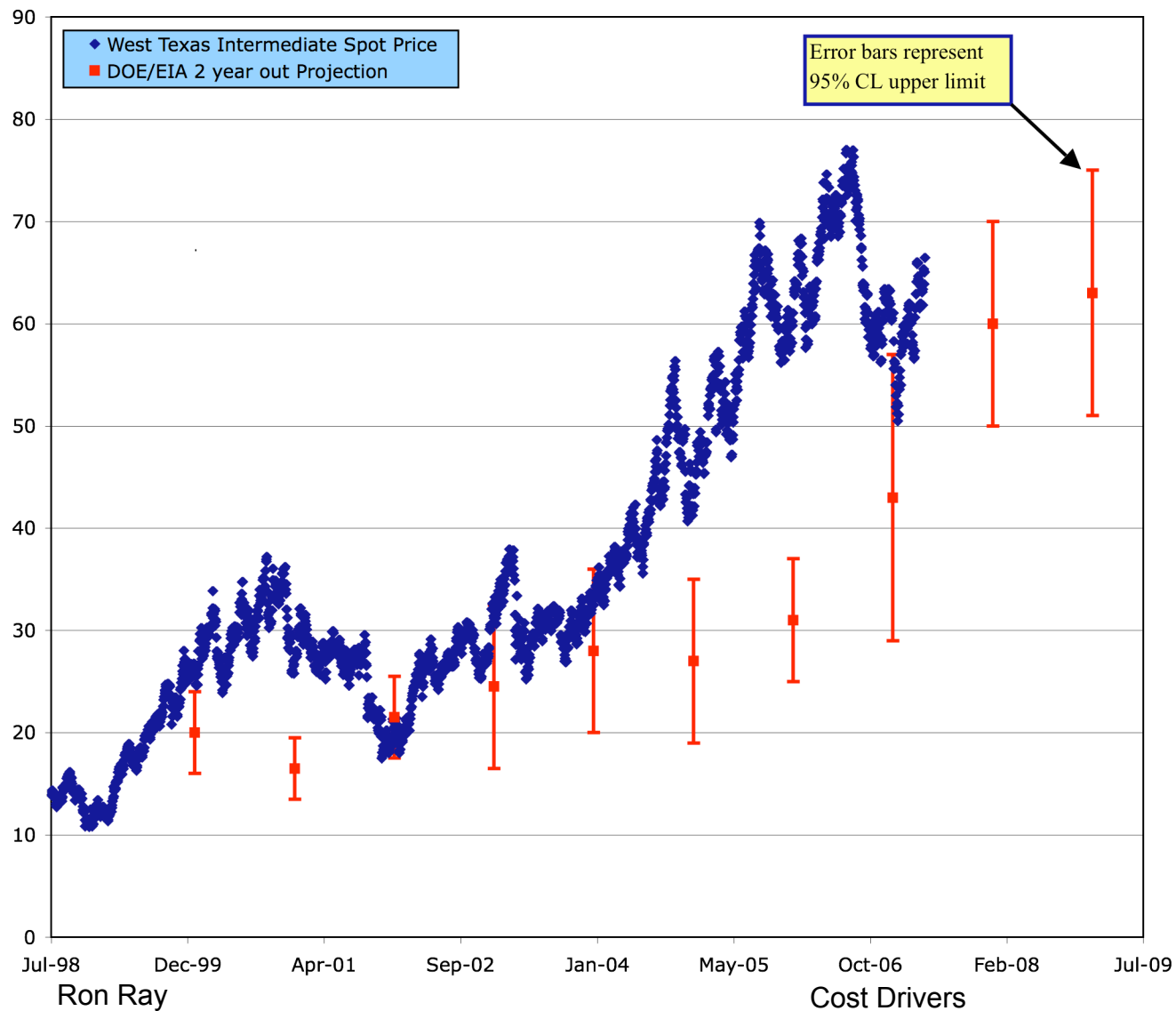
DOE short-term projection distribution only. No low side tail.



High-side tail extending to \$100/barrel. Tail beyond \$70 corresponds to 5% of area, consistent with historical data normalized to 2005 dollars.



# Comparison of EIA Model with Data



EIA 95% C.L. limit  
encompasses  
data 5 out of 8 times

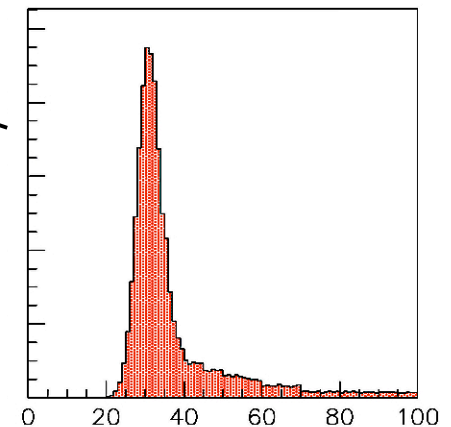


# Comparison of Our Model with Data



95% C.L. limit  
encompasses  
data 8 out of 8 times

Crude oil price  
distribution using EIA  
Model for Jan '06 with  
the addition of high-side  
tail from historical data.

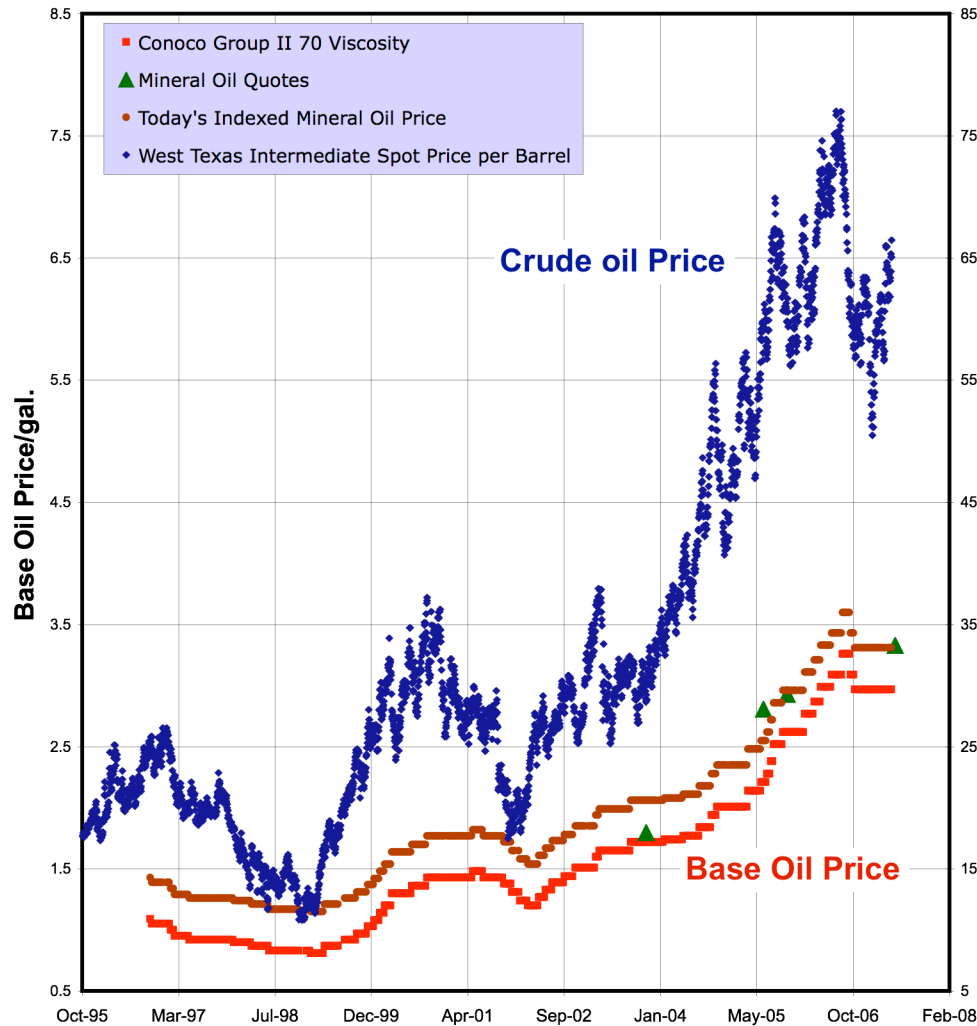




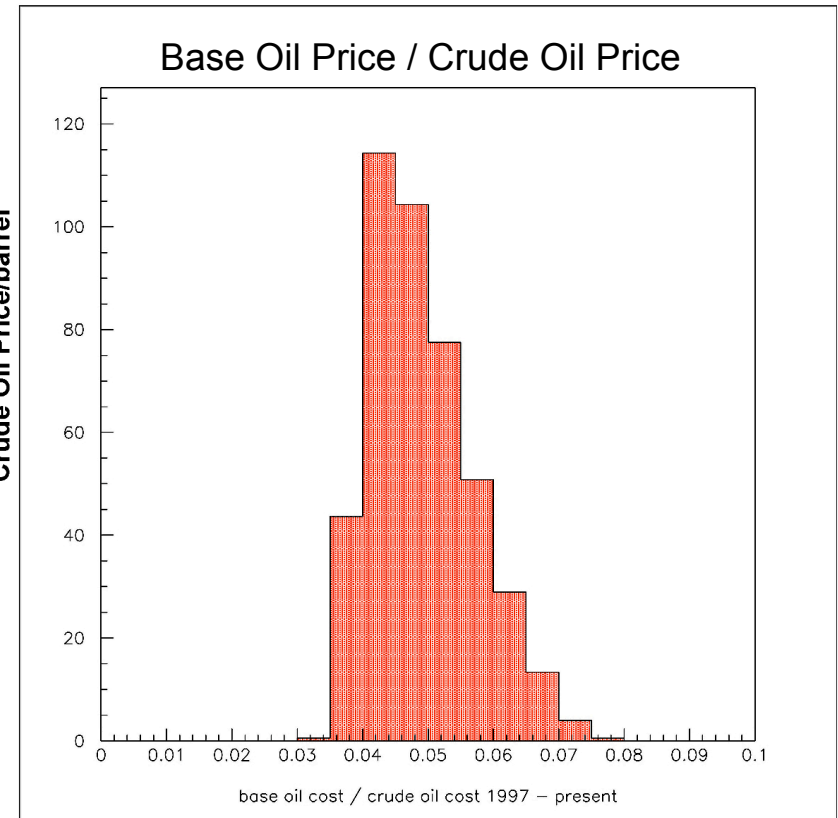


# Application to Mineral Oil

Mineral oil is refined from the heavy “base oils” left behind after the lighter crude components have been distilled off to make gasoline, diesel, jet fuel, etc.



Ron Ray



Cost Drivers





# Mineral Oil Contingency

Pick a mineral oil price from single-sided Gaussian distribution.

Assign 15% contingency based on rule #2 (firm quote, multiple vendors)

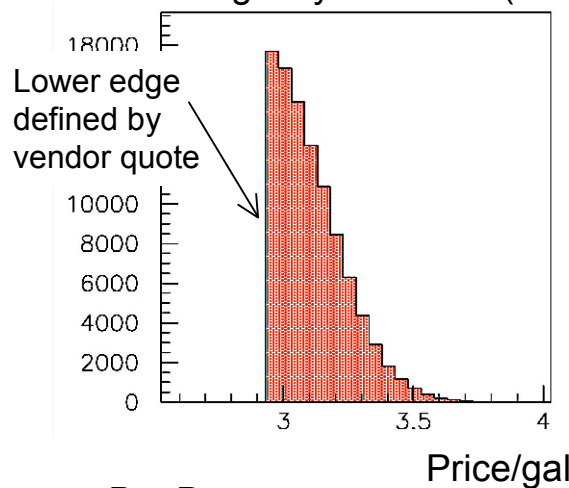
Pick a crude oil price.

Use deviation of crude oil price from \$60 to determine change in price for base oil. Add (or subtract) from mineral oil price.

Repeat 100,000 times

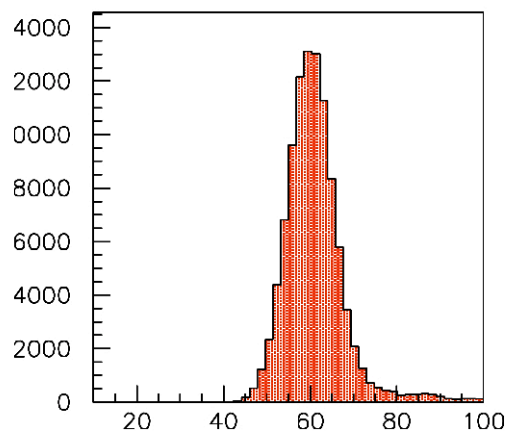
Mineral Oil Price Distribution +15%

Contingency at  $1.96 \sigma$  (95%)



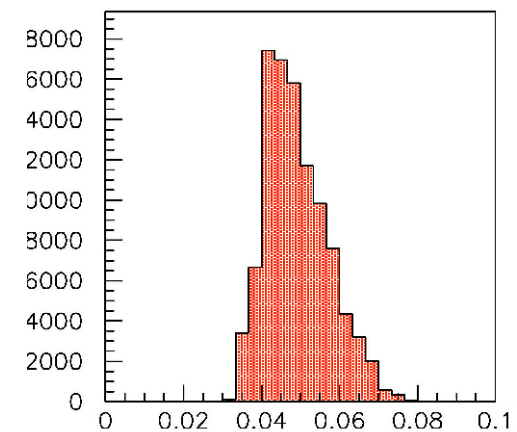
Ron Ray

Crude oil Price Distribution



Cost Drivers

Base Oil / Crude Oil Distribution from Historical Data



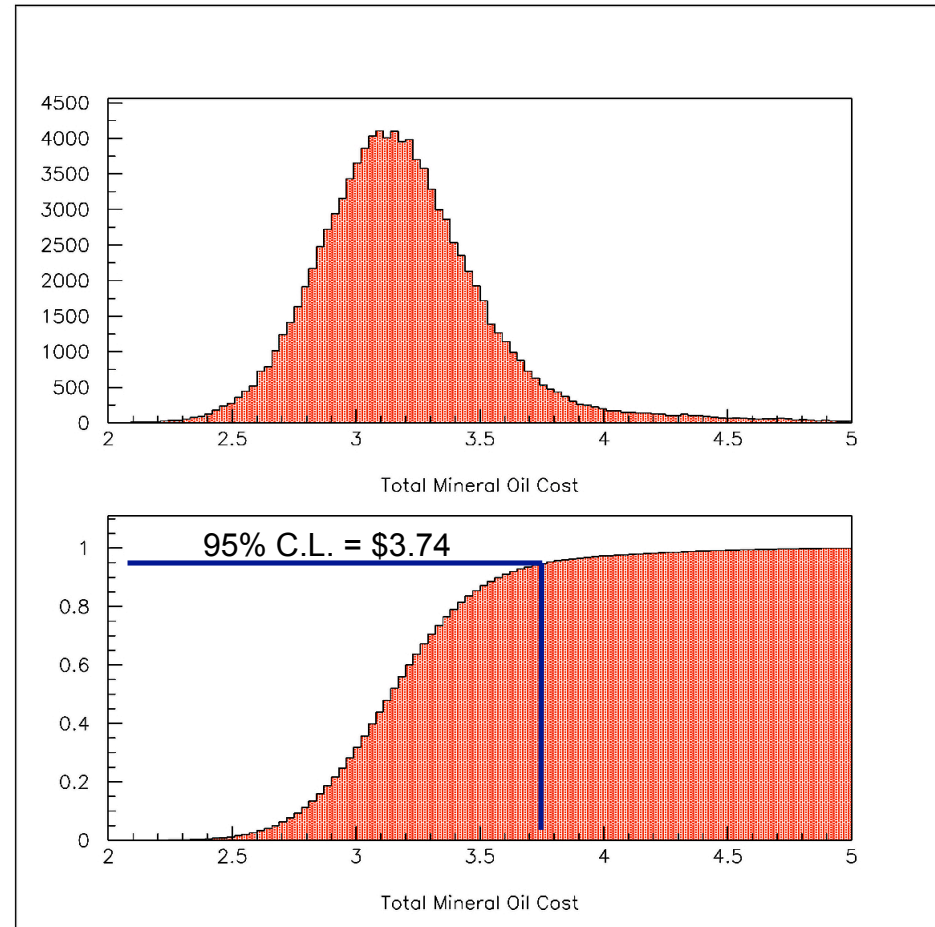
17



# Mineral Oil Contingency

From the probability distribution we have a 95% probability that the total cost of mineral oil (Base + contingency) will be less than \$3.74/gal for a base price of \$2.93/gal, transportation not included.

**This corresponds to a 28% contingency and is made possible because we have actual quotes .**





## PVC Resin

- Issued an RFP in June, 2006 for 35,000 lbs for the IPND with an option for 12,900,000 lbs.
  - Quote for full quantity was \$0.984/lb
  - Request was for *NOvA 2*, a rutile based formulation.
- Our baseline has evolved to ~12,000,000 lbs of *NOvA 27*, an anatase based formulation.
- In May 2007 we purchased 130,000 lbs of *NOvA 27* for the IPND and various R&D tasks at a cost of \$0.98/lb. Use this number for cost of the full ~12,000,000 lbs
- Crude oil and natural gas are used in the production of PVC. Using historical price information for PVC, crude oil and natural gas we have done a Monte Carlo calculation to determine the contingency of 30%.



# PVC Extrusions

- Mostly labor.
- Issued an RFP in Sept. 2005 for R&D quantities and an option for 12,900,000 lbs of PVC extrusions. Several unknowns at the time, so we assigned a 35% contingency.
- Many things have changed since then, so we have solicited a new quote for the base plan from the extruder who won the RFP competition.
- Still a few small uncertainties including waste factor, storage, etc.
- Assign a flat-rate contingency of 25%.
- Delivery is indexed to diesel fuel surcharge. Monte Carlo calculation results in a 34% contingency for extrusion delivery.

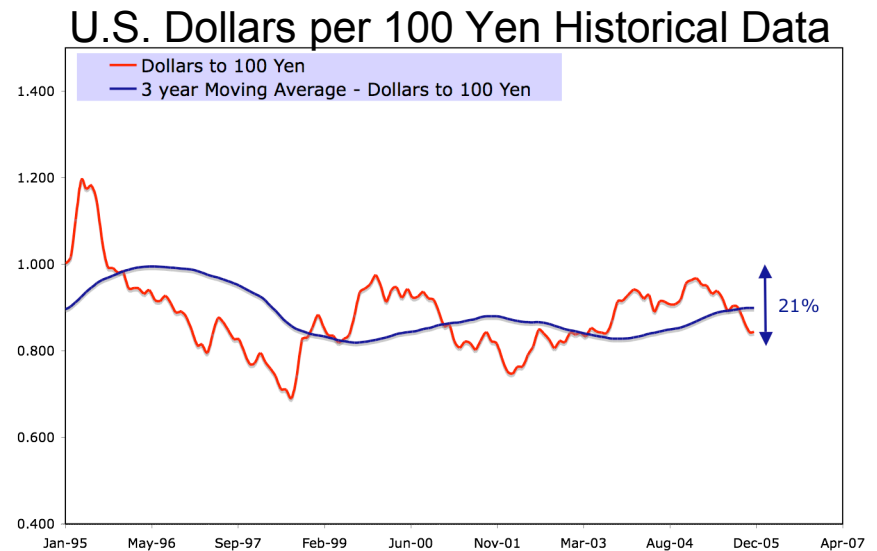


# WLS Fiber

- Sole source, foreign procurement from a well known supplier.
- We require about 18,000 km of fiber, down from 26,000 km.
- Original quotes were for 0.8 mm diameter fiber with 150 ppm of K27. We are now using 0.7 mm diameter fiber with a different K27 concentration (still to be determined).

- We have a firm quote for the required amount. Concentration of K27 has no impact on cost based on R&D quantities that we have procured.

- Quote from Kuraray includes a price adjustment to cover exchange rate fluctuations. Historical data for dollar-to-yen ratio used in Monte Carlo calculation of contingency.





## APDs

- Sole source foreign procurement, well known supplier.
- Custom part from Hamamatsu based on an existing part
- "Best guess" price between \$350 to \$425 per APD chip.
  - Price includes cost of carrier board and bump bonding
  - Use \$425.
- Assign a flat-rate contingency of 50%
- Add additional contingency based on historical currency fluctuations
- Total cost from Monte Carlo  $\leq$  \$671 per chip
- Overall contingency of 58%



# Major Contingencies

	Overall Contingency	Comments
Pseudocumene	25%	1 quote from China. 1 quote from US source, but only good for 90 days. No indexing.
Mineral Oil	28%	15% + dependence on crude. Monte Carlo. Transportation not included.
Mineral Oil Delivery	26%	15% + dependence on diesel/crude. Monte Carlo.
Trucking Scintillator	29%	25% + dependence on diesel/crude. Monte Carlo.
Waveshifters	25%	Firm quote, single source.
WLS Fiber	28%	15% + currency fluctuation. Monte Carlo.
PVC Resin	30%	15% for PVC, 30% for TiO <sub>2</sub> + dependence on natural gas + dependence on crude. Monte Carlo.
Extrusions	25%	Mostly labor and tooling.
APDs	58%	Only a best guess on price. 50% + currency fluctuation. Monte Carlo.
Building and Site	22%	DOE Cost Estimating Guide for conventional construction



# Summary

- We have firm quotes in hand for most of the cost drivers. This represents a significant fraction of the TPC. With a high degree of certainty we know how much this project costs.
  - As the project has evolved we have gone back to suppliers and asked for updated quotes.
  - The quotes are tied to various indices that allow us to track price evolution, determine the best time to buy and to set contingencies.
- We have identified high-risk components, defined additional contingency to cover the risk and added the contingencies together following the guidance in *DOE 413.3*.